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# Detection of Protons in CR-39 Plastic Track Detector

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Y. V. RAO
A. DAVIS
R. C. FILZ
P. J. McNULTY
D. SHIRKEY




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AIR FORCE GEOPHYSICS LABORATORY
HANSCOM AFB, MASSACHUSETTS 01731


AIR FORCE SYSTEMS COMMAND, USAF

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FOR THE COMMANDER

John Howard

Chief Scientist

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**Physics Research Division, Emmanuel College, Lexington, Mass.

***Physics Department, Clarkson College of Technology, Potsdom, N.Y.

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CR-39 plastic is used as a detector to observe monoenergetic protons. Several samples of CR-39 were exposed to protons of energies 1.5 MeV, 2.2 MeV, 3.2 MeV and 4.3 MeV. After etching measurements were carried out on track diameters produced by protons in all samples. The diameter distributions clearly show an excellent energy resolution of protons of different energies. From our preliminary analysis of data, it appears that the response function for registering protons in CR-39 may be a lot less complicated than in cellulose nitrate.

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## Preface

It is a pleasure to thank Drs. Norman Rohrig and Steve Marino of Brookhaven National Laboratory for help with proton irradiations.

## Contents



## Illustrations

# Detection of Protons in CR-39* Plastic Track Detector

## 1. INTRODUCTION

In recent years Solid State Nuclear Track Detectors have found widespread application.[1] The production of tracks by energetic ions in insulating materials is a widely used technique for detection and identification of these ions. The use of these detectors has been shown to be very successful in the study of very heavy primary cosmic rays and the recording of fission fragments. Also, there have been some investigations exploring the possibility of their application to detect protons. Cellulose Nitrate plastic has been employed as a detector to record protons, however, CN suffers from being inhomogeneous and anistropic with regard to its physical characteristics. These defects manifest themselves in non-geometrical track profiles, differences in sensitivity in a given sheet, and variations in bulk etch rate. The use of plastic sheet cast from CR-39 monomer (allyl diglycol carbonate) with excellent etching properties, high sensitivity and high uniformity as a nuclear track detector was reported recently.[2] This material was found to

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*Registered Trade Mark, Pittsburgh Plate Glass.

1. Fleischer, R. L., Price, P. B., and Walker, R. M. (1975) Nuclear Tracks in Solids, University of California Press, Berkeley.
2. Cartwright, B. G., Shirk, E. K., and Price, P. B. (1978) Nucl. Instr. Methods 153:457.

have a lower detection threshold ($Z/\beta$ = 9) than cellulose nitrate ($Z/\beta$ = 30) and a smaller variation of response (~ 1 percent) to particles of a given ionization rate than Lexan polycarbonate (~ 3 to 8 percent). Commercially available CR-39 is capable of recording protons of 1 MeV and below as well as 6 MeV alpha particles. In this work, an attempt is made to investigate further the properties of CR-39 as a nuclear track detector with particular reference to the detection of protons.

## 2. EXPERIMENTAL DETAILS

For this study, Polytech CR-39 (1500 $\mu$ thick) was used. Samples of size (2.5 × 2.5) cm were cut out and exposed to a beam of protons from the Van de Graaf generator at Brookhaven National Laboratory. The beam was tuned to four different energies (1.5 MeV, 2.2 MeV, 3.2 MeV and 4.3 MeV). The corresponding fluences were: $2.8 \times 10^5$ particles/cm$^2$, $0.44 \times 10^6$ particles/cm$^2$, $0.67 \times 10^6$ particles/cm$^2$ and $0.91 \times 10^6$ particles/cm$^2$. All irradiations were carried out in such a manner that particles are nearly normally incident to the surface of the plastic sheet. After irradiation the samples were etched in a solution of 6.25N NaoH at 50$^o$C for different durations. The samples were suspended by means of nichrome wires in polyethylene vessels containing etchant. Temperature control was achieved by placing the polyethylene containers into a regulated water bath. Samples were selected from all four irradiations and etched in four different batches for 7 hours, 17 hours, 30 hours and 48 hours. In order to distinguish the background against tracks of protons, a virgin sample of CR-39 was always etched with each batch. All measurements were made on Koristka R4 microscope using 80 Zeiss objective and X10 wide field American Optical eyepiece. A total of 1000 tracks were measured to obtain data on track diameters.

## 3. RESULTS

In Figures 1 and 2 the distributions of track diameters for protons are shown. The sheets were etched for 17 hours and 30 hours. In the case of the 17 hour etch, there is some spread in track diameter distribution for 4.3 MeV protons. This may be of statistical nature and/or spread in the beam energy. The superior properties of CR-39 as a track detector is clearly demonstrated in Figure 2. Here, the energy resolution for protons is excellent. Once again the peak in track diameter distribution for 4.3 MeV protons is very broad. Figure 3 shows etch pit diameter as a function of proton energy. The samples etched for 48 hours show a maximum slope thereby indicating a better resolution. Figure 4 shows etch pit

diameter as a function of amount of bulk material removed from one surface. From our preliminary data, it appears that the dependence of etch pit diameter on the amount of bulk material removed from one surface seems to be less complicated than in CN. Particle identification by measurements of etch pit diameter was first suggested by Somogyi.[3] Recently, Somogyi and Szalay[4] discussed the kinetics of track diameter growth in considerable detail. In principle the method should work with particles incident at arbitrary angles on a solid surface, but in practice it is much simpler if the detector can be positioned such that particles are nearly normally incident. For tracks with large cone angles such as protons, the diameter is a more sensitive function of ionization rate than is track length. Finally, Figures 5 and 6 show tracks of 1.5 MeV and 2.2 MeV protons.

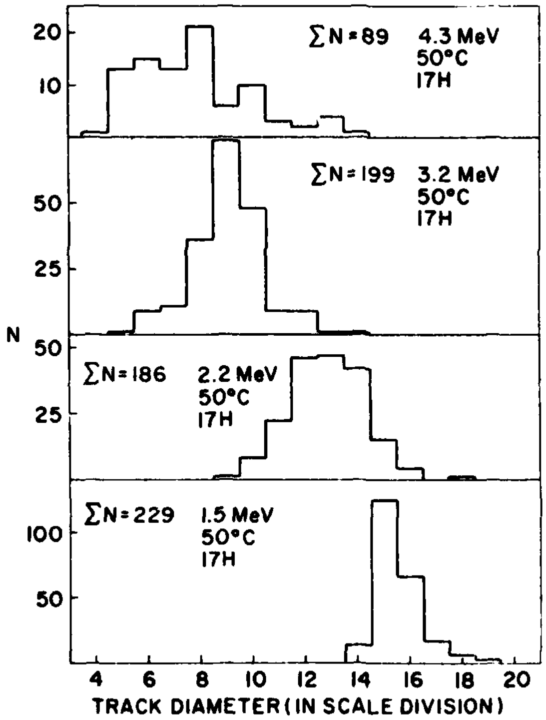


Figure 1. The Diameter Distribution of the Etch Pits of Protons (17 hour etch)

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3. Somogyi, G. (1966) Nucl. Instr. Methods 42:312.
4. Somogyi, G., and Szalay, S.A. (1973) Nucl. Instr. Methods 109:211.

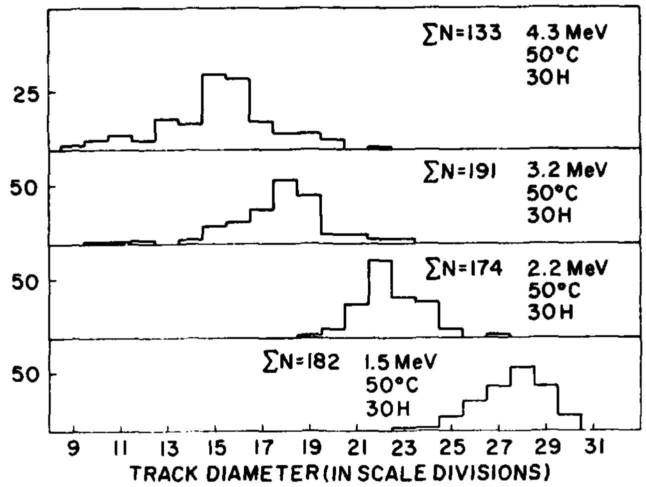


Figure 2. The Diameter Distribution of the Etch Pits of Protons (30 hour etch)

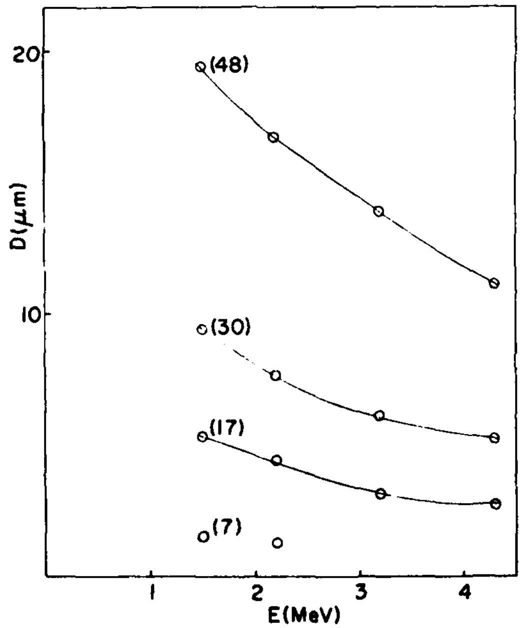


Figure 3. Etch Pit Diameter (D) as a Function of Proton Energy (E). The parameter on each curve represents etching time

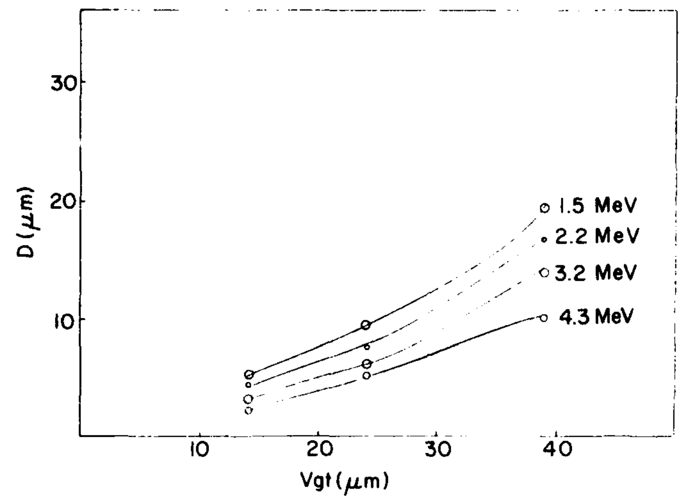


Figure 4. Etch Pit Diameter (D) as a Function of Amount of Bulk Material Removed From One Surface (Vgt)

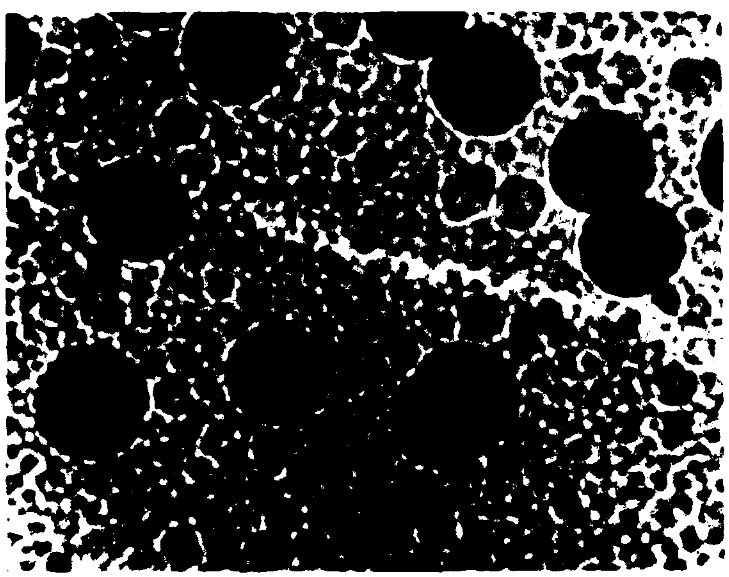

Figure 5. Tracks of 1.5 MeV Normal Incidence Protons in CR-39. The etching time was 30 hours

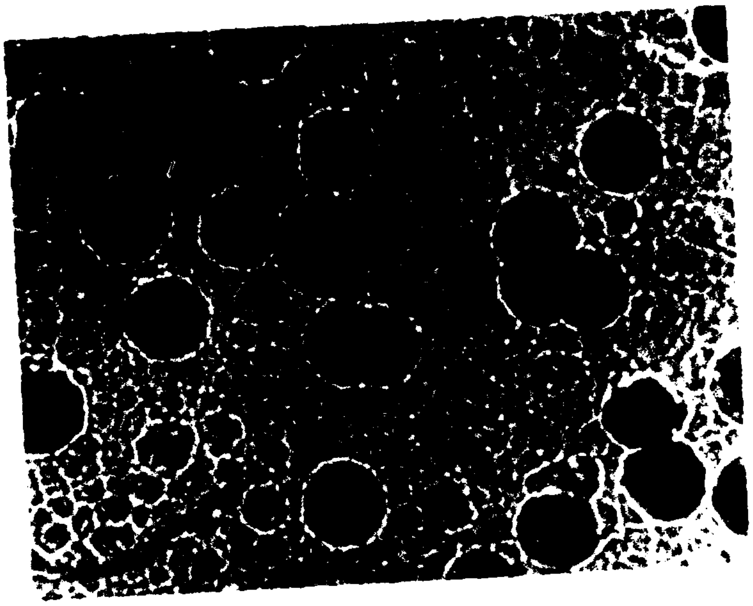

Figure 6. Tracks of 2.2 MeV Normal Incidence Protons in CR-39. The etching time was 30 hours